2002

2001

2000

1998

*Thermal testing*

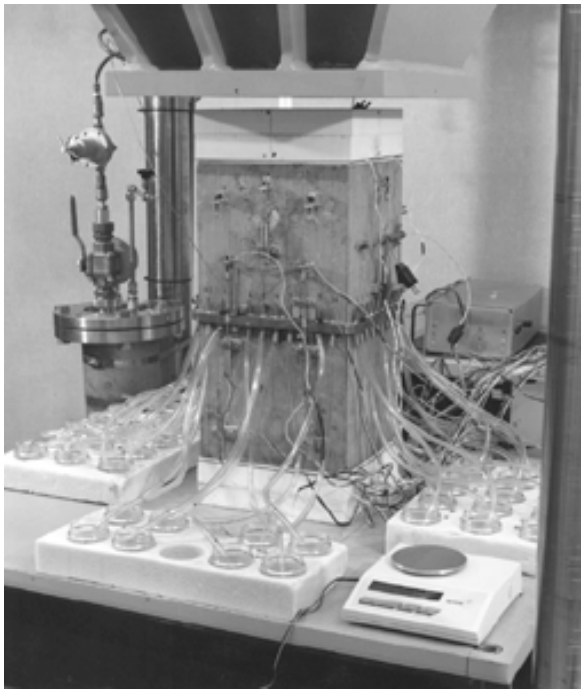
# Heating tests help scientists predict rock's behavior

In December 1997, researchers at Yucca Mountain, Nevada, switched on the most extensive of four types of thermal tests of Yucca Mountain rock. These tests, some of which will go on for several years, are designed to show how heat from spent nuclear fuel and high-level radioactive waste will affect the nearby rock.

The latest test, the Drift-Scale Test, called for heating a 47-meter- (155-foot)-long tunnel in Alcove 5 of the Exploratory Studies Facility (ESF) to temperatures of up to 200 degrees Celsius (392 degrees Fahrenheit). The tunnel segment is slated to remain heated for about four years. Scientists conducted their experiment in a test tunnel roughly the same size and shape as those that would store waste canisters in a repository. Researchers designed the Drift-Scale Test to reach the temperatures anticipated in a repository.

## From small and simple to bigger and more complex

Researchers have been conducting laboratory-scale thermal tests of Yucca Mountain rock at several national and private scientific facilities on a periodic basis since the start of the Project. In these experiments, they heat small blocks of this rock for short amounts of time. Researchers study these blocks in the laboratory under highly controlled conditions. The latest series of thermal laboratory tests, which helped set the stage for the larger field tests, is slated to continue throughout the duration of these field tests.



Scientists test heat effects on a small block of Yucca Mountain rock under laboratory conditions.

Data from these laboratory tests have provided a basis from which to measure progressively larger heat tests, held under less controlled and increasingly realistic conditions. Prolonged heat triggers mechanical, hydrological, and chemical, as well as thermal, changes in rock. The controlled laboratory setting made it possible for researchers to isolate these individual processes, study their possible and probable interactions, and then build models showing how the rock might perform in nature. These models would be refined through subsequent field and laboratory studies. Researchers thereby moved from small scale to larger scale tests, from simpler

to more complex tests, and from tests of short duration to tests of many years.

## Large-Block Test examines rock under field conditions

The Large-Block Test moved thermal studies out of the laboratory and into the field. The test took place on the surface near Yucca Mountain. Scientists carved out a three-by-three-by 4.5-meter (10-foot-by-10-foot-by-15-foot) block of rock from the same geologic formation as that proposed for a repository. Heating of the block began in February 1997. The cooling phase began in January 1998.

In this test, the block of rock was covered with insulation and with vapor seals designed to catch any moisture that moves through the rock during heating. The heat was supplied by five three-meter-long electrical heaters with a combined output of 2,250 watts. After the rock cools, it will be carefully broken apart. Scientists will study their samples for changes to the rock's chemistry, as well as for the presence of any microbiological organisms. Such organisms could, under certain conditions, potentially corrode waste canisters

## A large-scale Single-Heater Test looks at rock's response underground

A large-scale Single-Heater Test began in August 1996. The electric heaters were turned off in May 1997, and the cool-down phase ended in 1998. In this test, researchers heated an approximately 20-cubic-meter volume of rock to more than 100 degrees Celsius (i.e., 26 cubic- yards to 212 degrees Fahrenheit). An additional 1,600 cubic meters (2093 cubic yards) of nearby rock were affected as well by the heat. Unlike previous thermal tests, this one took place in a test alcove 300 meters (984 feet) below the surface of the mountain. This gave researchers less ability to control the experimental conditions. But it also more closely approximated those found in a repository.

Designed as a prelude to the final Drift-Scale Test, this experiment allowed researchers to more closely re-create some of the conditions that would be found in a repository. In this test, scientists used a copper-wrapped

Exploratory Studies Facilities workers install electric cables in one of the nine canisters used to simulate repository emplacement canisters. Thirty electric heaters are contained within each canister. This test will continue for several years.

Project officials check data collected from the Single-Heater Test in Alcove 5.

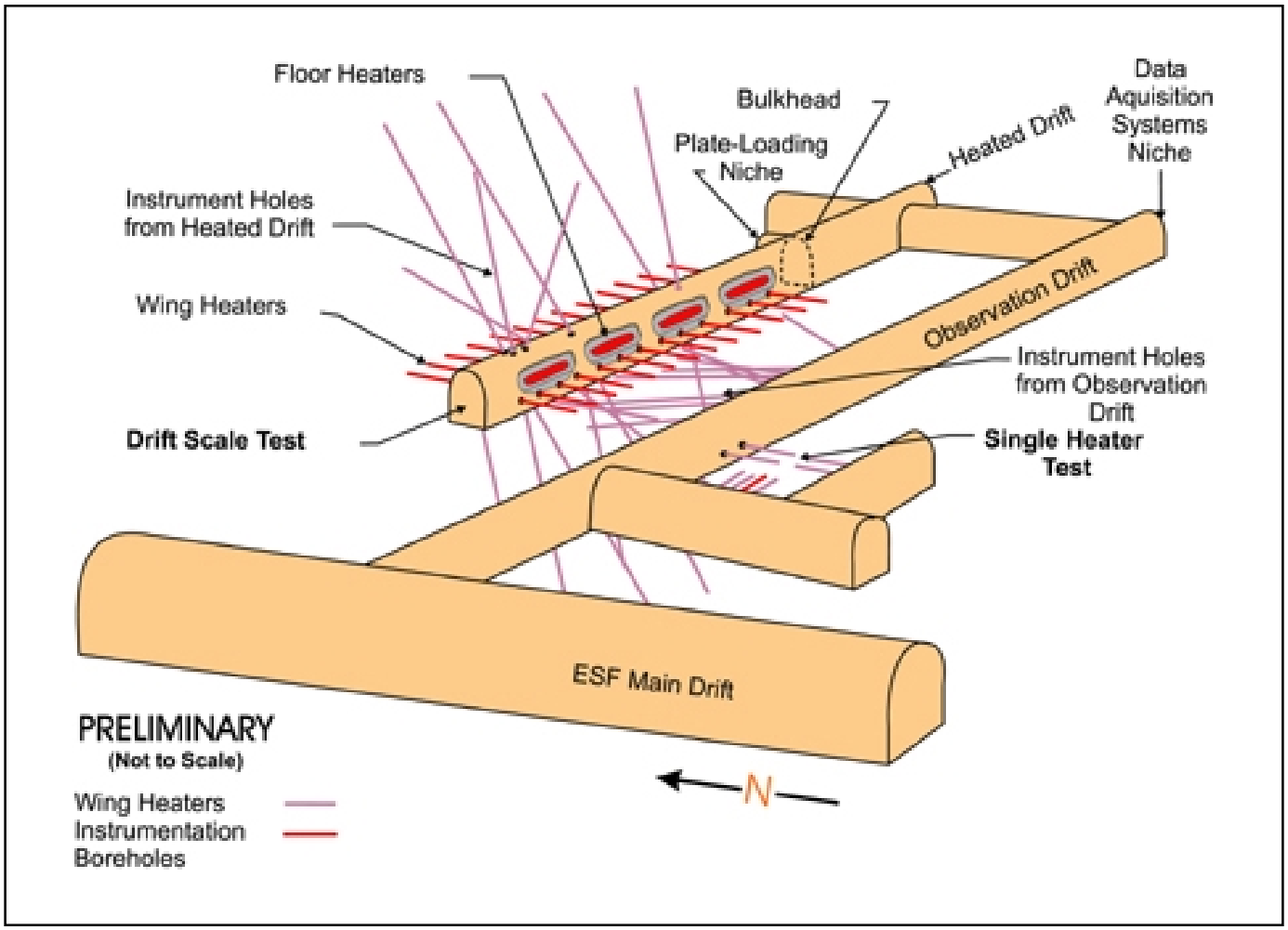
electrical heater some 10 centimeters (4 inches) in diameter and roughly the length of a standard flag pole. They inserted it into a borehole drilled near the center of the test block. They used 300 thermal sensors to monitor temperatures during the experiment.

## Drift-Scale Test examines near-repository conditions

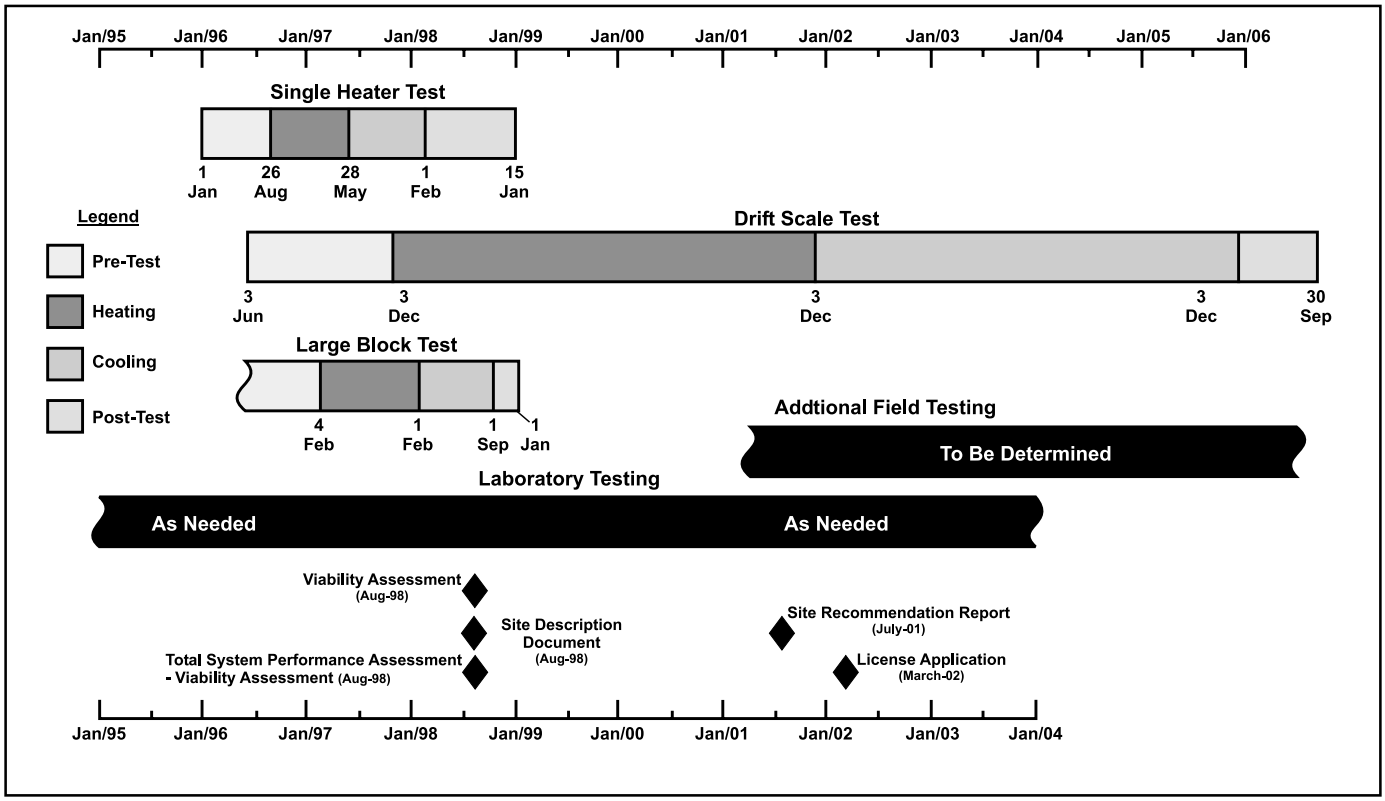
Scientists designed the Drift-Scale Test, which began in December 1997, as the largest experiment in their multi-year study of heated rock. Previous thermal tests looked at progressively bigger volumes of rock under conditions that were increasingly more difficult to control.

With the Drift-Scale Test, researchers will come closest to creating the thermal conditions that would exist in a repository. In this test, they heat approximately 10,000 cubic meters of rock to 100 degrees Celsius (that is, 13,000 cubic yards of rock to 212 degrees Fahrenheit). Overall, though, 200,000 cubic meters (260,000 cubic yards) of nearby rock is affected by the heat. The heat will be generated by nine electrical floor heaters, and by another 50 electrical side heaters.

The heated tunnel is insulated from the rest of the alcove. Remote video and infrared cameras permit researchers to monitor the sealed tunnels visually.




During the Drift-Scale test, an alcove approximately 50 meters (164 feet) in length will be heated over a period of several years by electric heaters placed on the floor and in the walls of the drift. The floor heaters will be similar in dimensions to the waste canisters that would be stored in the potential repository.




Schedule for the Exploratory Studies Facility Thermal Test Strategy.

Some 4,000 sensors installed in the surrounding rock help scientists monitor the various kinds of heating effects.

Scientists will collect and evaluate data from the Drift-Scale Test and other thermal tests for several years. The knowledge they gain will permit them to make better assessments of the potential repository's future long-term performance.

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

YUCCA MOUNTAIN
SITE CHARACTERIZATION
PROJECT

P.O. Box 30307
North Las Vegas, NV 89036-0307
1-800-225-6972
http://www.ymp.gov

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